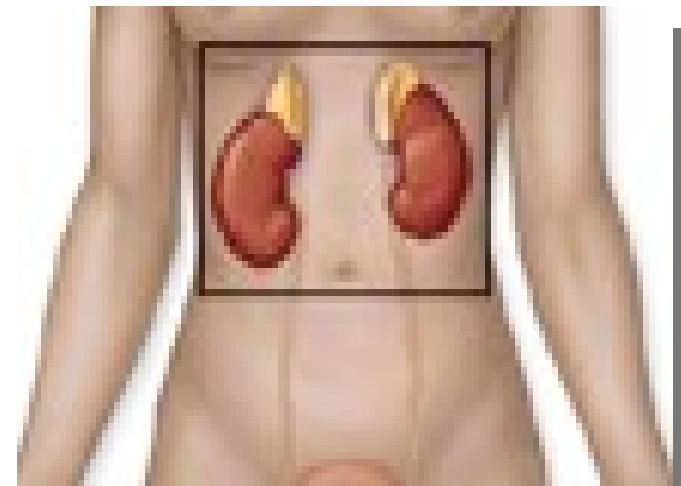
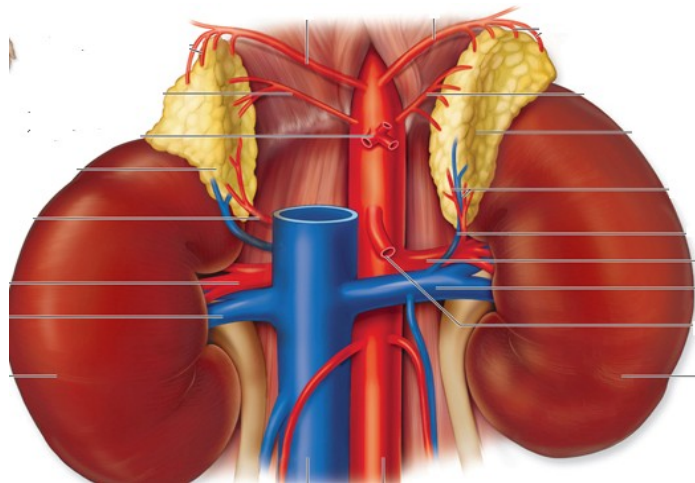




Armed Forces College of Medicine AFCM



Physiology of adrenal glands (3)

By

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INTENDED LEARNING OBJECTIVES (ILO)



- By the end of this lecture (3), the student will be able to:
 - 1- Identify the effects of excess secretion of adrenal androgens.
 - 2- Identify the causes and manifestations of primary adrenocortical insufficiency.
 - 3- Enumerate a disease state caused by over-secretion of adrenal catecholamines and how to diagnose this disease..

Adrenal sex hormones



- **Site:**

Zona reticularis of adrenal cortex.

- Their amount is insignificant compared to the amounts secreted by the gonads.

1- Dehydroepiandrosterone (DHEA).

2- Estrogens.

- **Function:**

- Growth of axillary & pubic hair in **both** ♂ and ♀ .
- The onset of puberty (pubertal growth spurt) in **both** ♂ & ♀
- Secretion of the adrenal androgens is controlled by ACTH, **NOT** by gonadotropins.

Disorders of Adrenal Cortex



Hypersecretion

Conn's disease

Cushing's Syndrome

↑ **Aldosterone**

↑ **Cortisol**

Adrenogenital syndrome
(sex hormones)

Hyposecretion

Addison's disease

↓ **Cortisol**
↓ **Aldosterone**

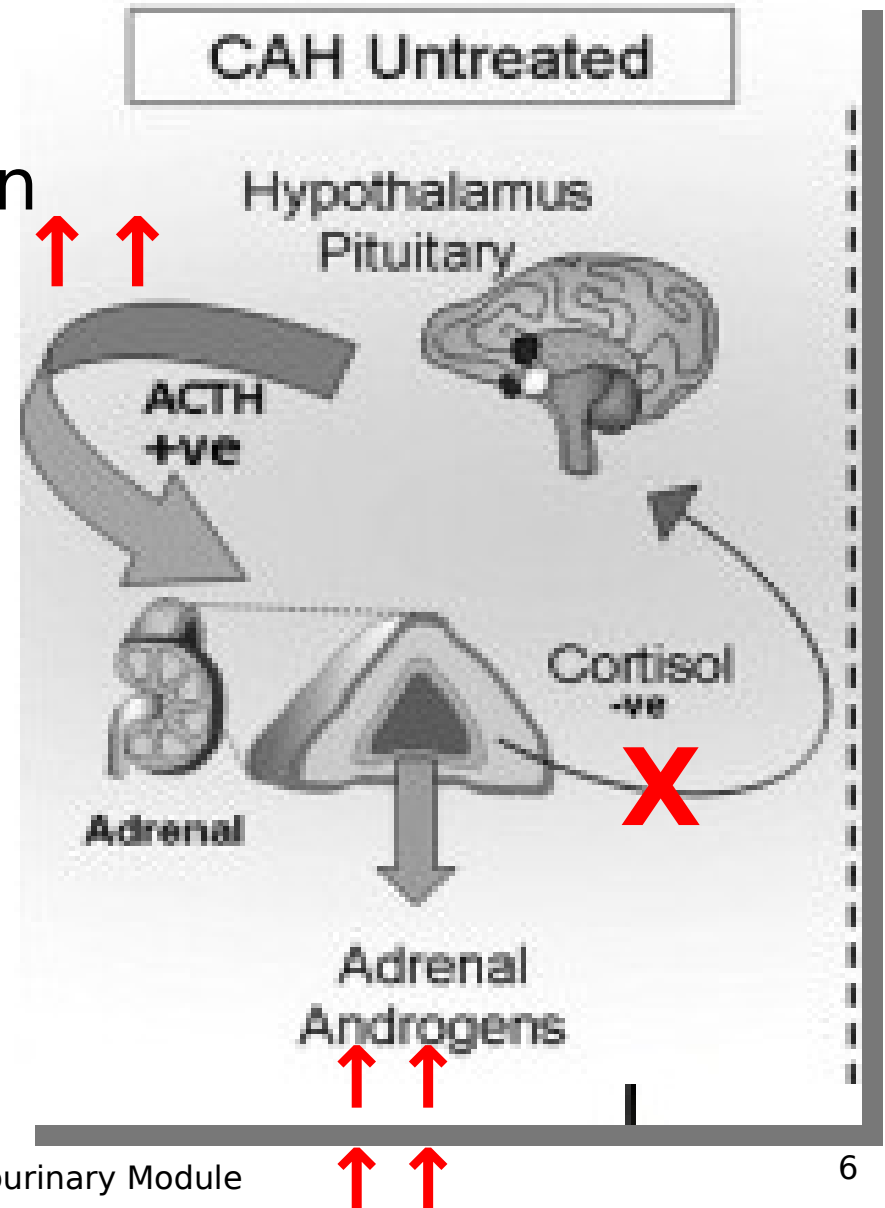
Adrenogenital syndrome



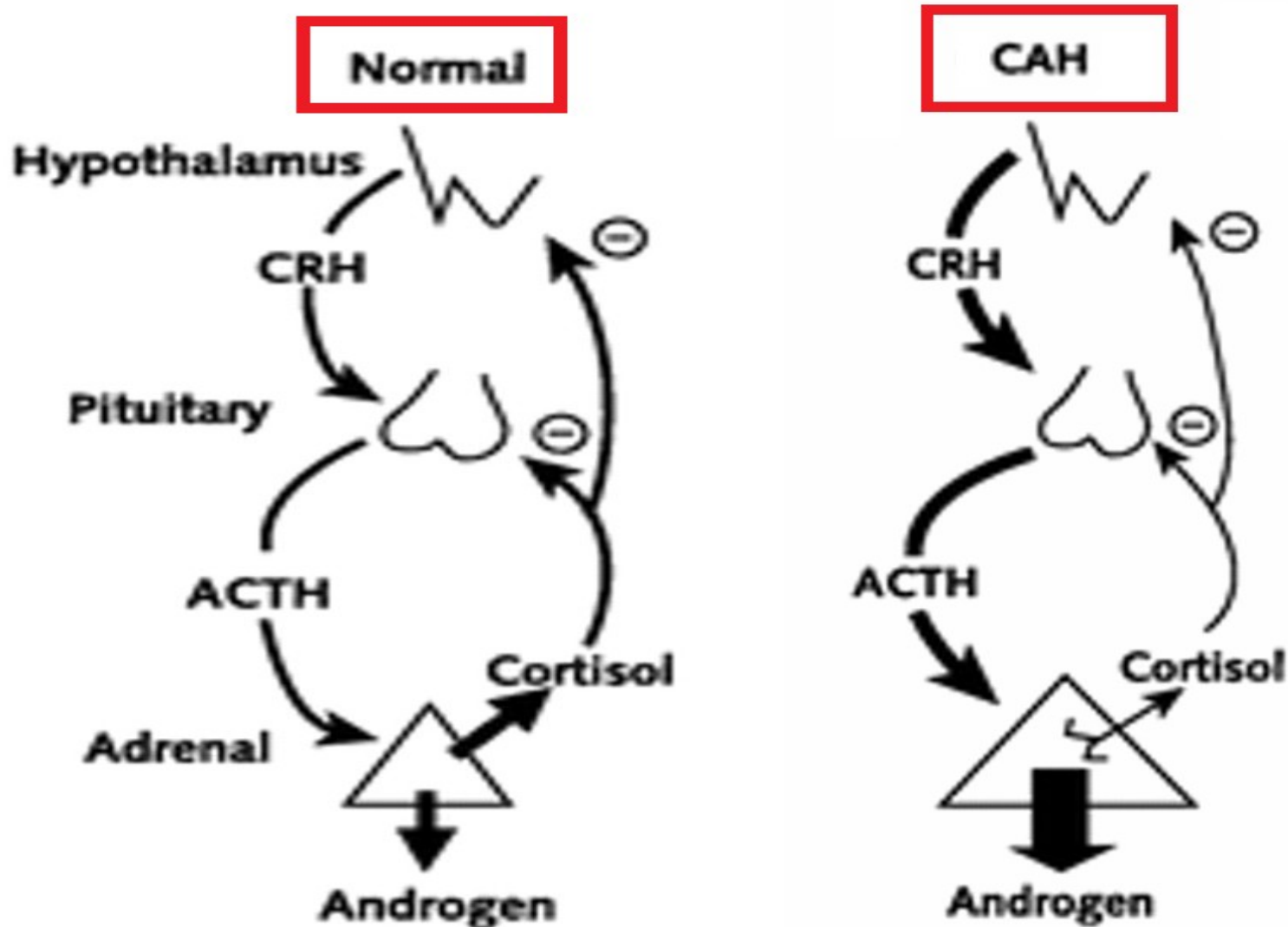
■ Cause:

- Excess adrenal androgen secretion from Z. reticularis.
- Due to congenital deficiency of some enzymes causing deficient cortisol secretion.

(e.g *21 β hydroxylase enzyme*)



Adrenogenital syndrome



Adrenogenital syndrome

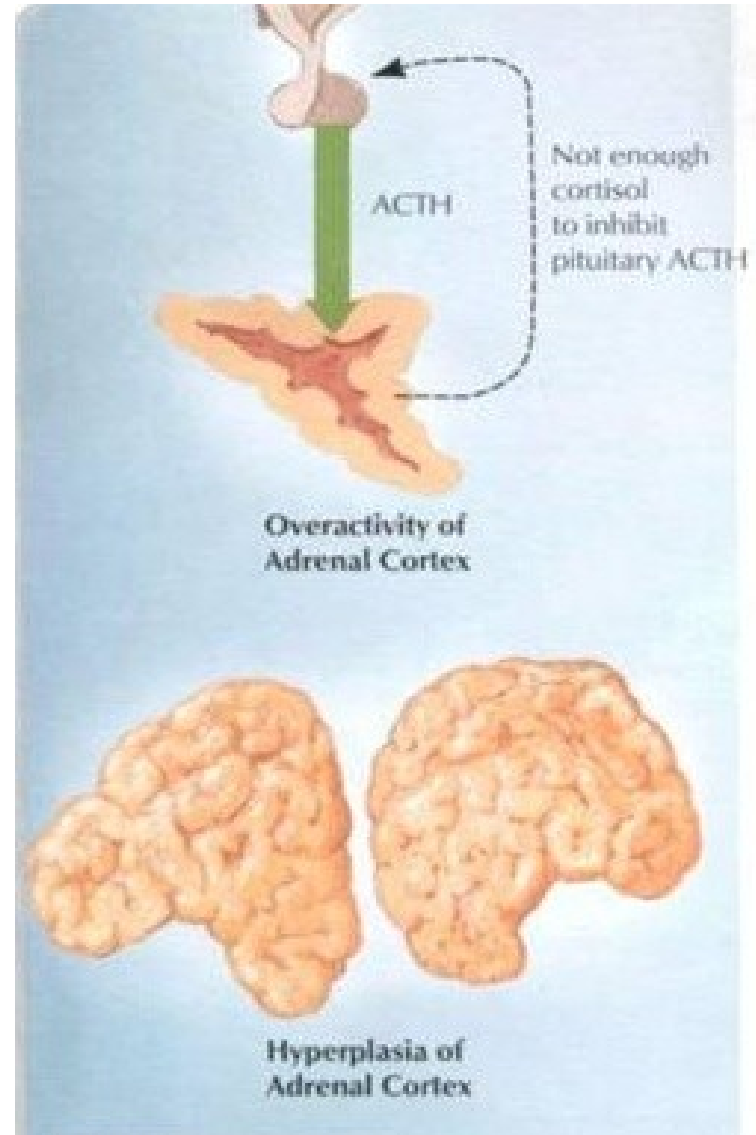


- **↓ Cortisol**

- removes the -ve feedback on hypothalamus & anterior pituitary
- ↑ ACTH which (+) adrenal cortex
- ↑ androgen secretion.

= **(Congenital adrenal hyperplasia).**

- The symptoms depend on the **age** & **sex** of the individual when the hyperactivity begins



Adrenogenital syndrome



in females

**Before
birth**

After puberty

Pseudo-hermaphrodite

**Growth of external genitalia
in a male pattern.**



Virilism

**Hirsutism, deep voice
& increase muscle bulk.**



Adrenogenital syndrome



in males

**In young
male**

In adult male

**Precocious
pseudopuberty**

**No
apparent effect**

- Early development of 2ry sexual characters without testicular activity and without sperm production.
 - e.g deep voice, beard, enlarged penis.
- because of the already existing male sex characteristic.

Disorders of Adrenal Cortex



Hypersecretion

Conn's disease

Cushing's Syndrome

↑ **Aldosterone**

↑ **Cortisol**

Adrenogenital syndrome
(sex hormones)

Hyposecretion

Addison's disease

↓ **Cortisol**
↓ **Aldosterone**

Adrenocortical insufficiency



- **Causes:**

- I. Primary (Addison's disease) due to:***

- Destruction of adrenal gland by auto-immune disease.
 - ✍ Destruction of adrenal gland by tuberculosis.

- II. Secondary due to:***

- ✍ Deficiency of ACTH (pituitary hypofunction)

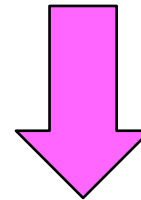
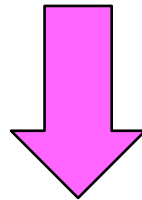
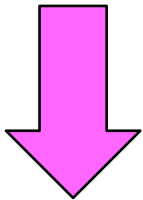
- **Symptoms of Addison's disease:**

Aldosterone

Cortisol

Sex

hormones

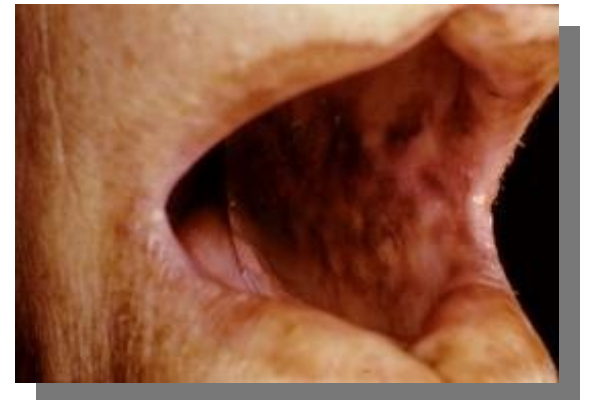


Aldosterone

- Hyponatremia (due to Na^+ loss).
- Hypotension: **why?**
 - \downarrow aldosterone \square hyponatremia.
 - \downarrow cortisol \square \downarrow vascular response to CAs.
 - If severe hypotension & shock \square Addisonian crisis
- Hyperkalemia \square cardiac arrhythmias.
- Metabolic acidosis (due to H^+ retention)

↓ Cortisol


- Hypoglycemia (↓ gluconeogenesis).
- Hypotension.
- Hyperpigmentation in skin & mucous membrane (↑ ACTH which has MSH-like activity).
- Fatigue, malaise, weakness & weight loss.
- Poor response to stress.
- Anaemia.




Sex hormones

- The deficiency of adrenal sex hormones usually has little effect in the presence of normal testes or ovaries.

Collectively,

 **Hypo** ☐ hyponatremia.
☐ hypotension.
☐ hypoglycemia.

 **Hyper** ☐ hyperpigmentation.
☐ K+.
☐ H+.

Symptoms:

Fatigue, lassitude, malaise, weakness, anorexia

Postural dizziness, syncope

Gastrointestinal Symptoms

- *Nausea*
- *Vomiting*
- *Abdominal Pain*
- *Diarrhea*
- *Constipation*

Myalgias, arthralgias,



Signs:

Weight loss

Hyperpigmentation

Hypotension

Thinning of axillary and pubic hair



Hyperpigmentation in Addison's Disease



Senator John F. Kennedy (presumably before the use of steroids notice the slender face)

Photo courtesy: <http://www.historyplace.com/kennedy/president.htm>

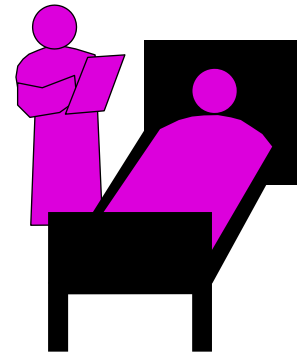


President John F. Kennedy's presidential picture with a more visible, round "moon" like face.

Photo courtesy: jfklibrary.org

Addisonian Crisis

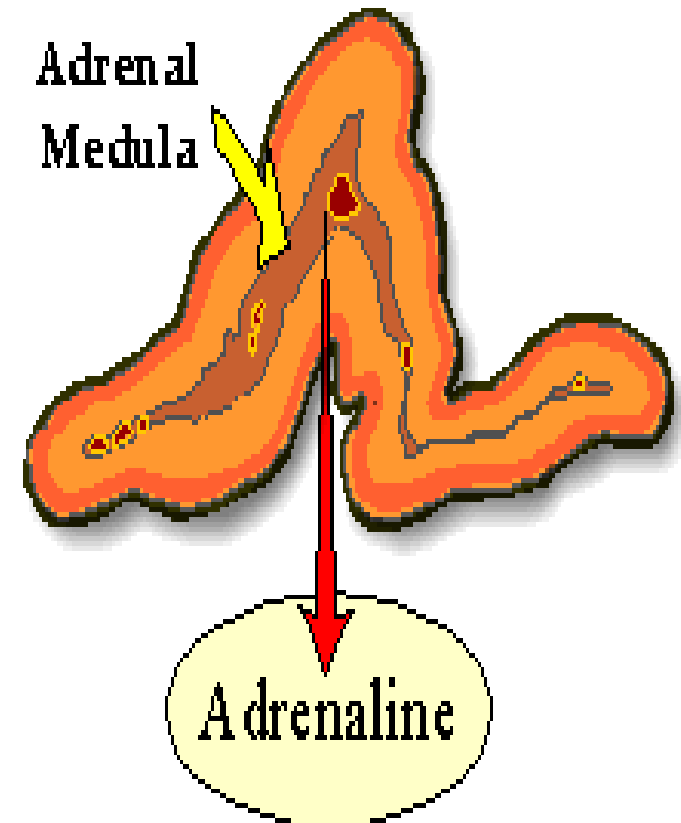
- Exposure to stresses in patients with Addison's disease
 - severe hypotension, hypoglycaemia, hyperkalaemia, severe vomiting and diarrhea and hypovolemic shock even death.
- **Other causes:**
 - ✍ Sudden withdrawal of GC.
 - ✍ Bilateral adrenalectomy.
- **Treatment:**
 - IV glucocorticoids and isotonic NaCl infusion.



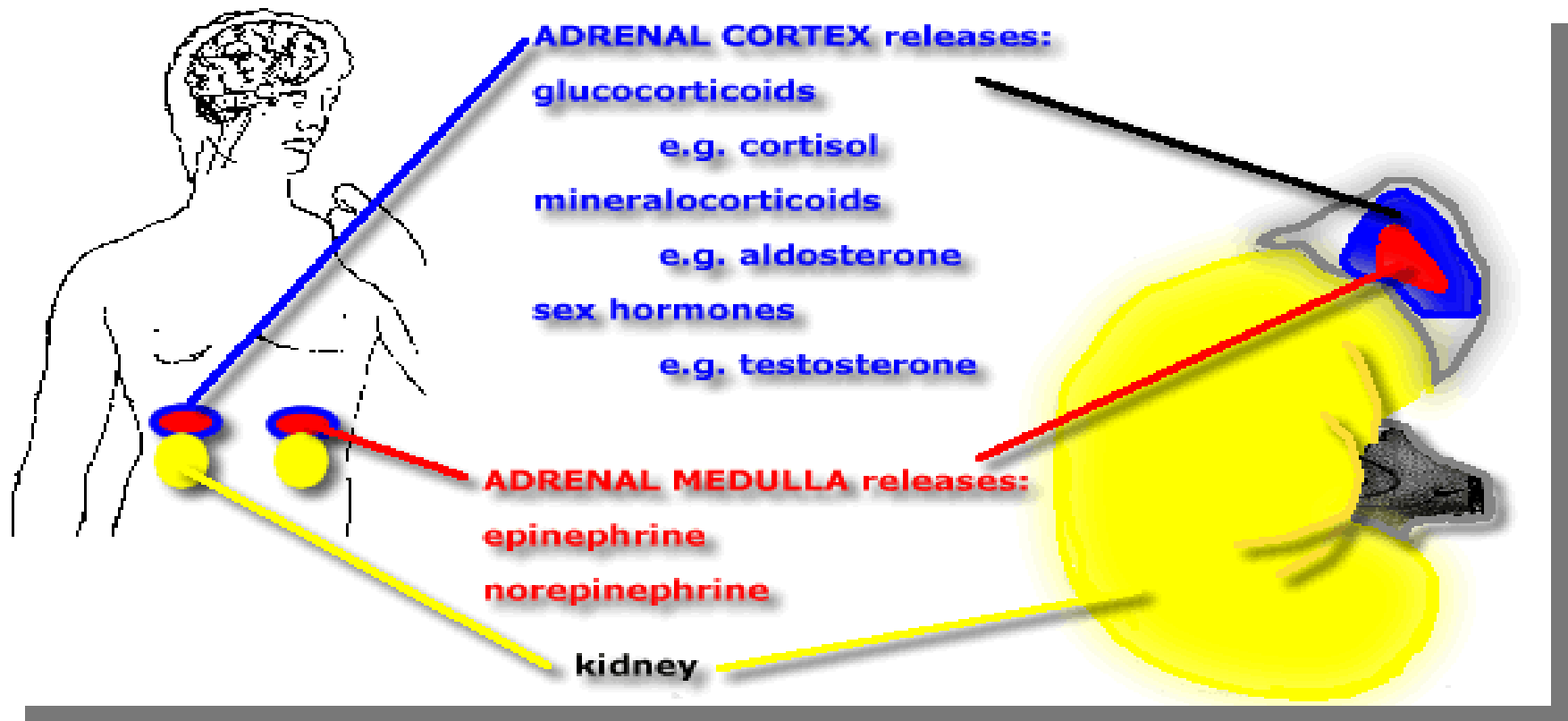
The adrenal medulla



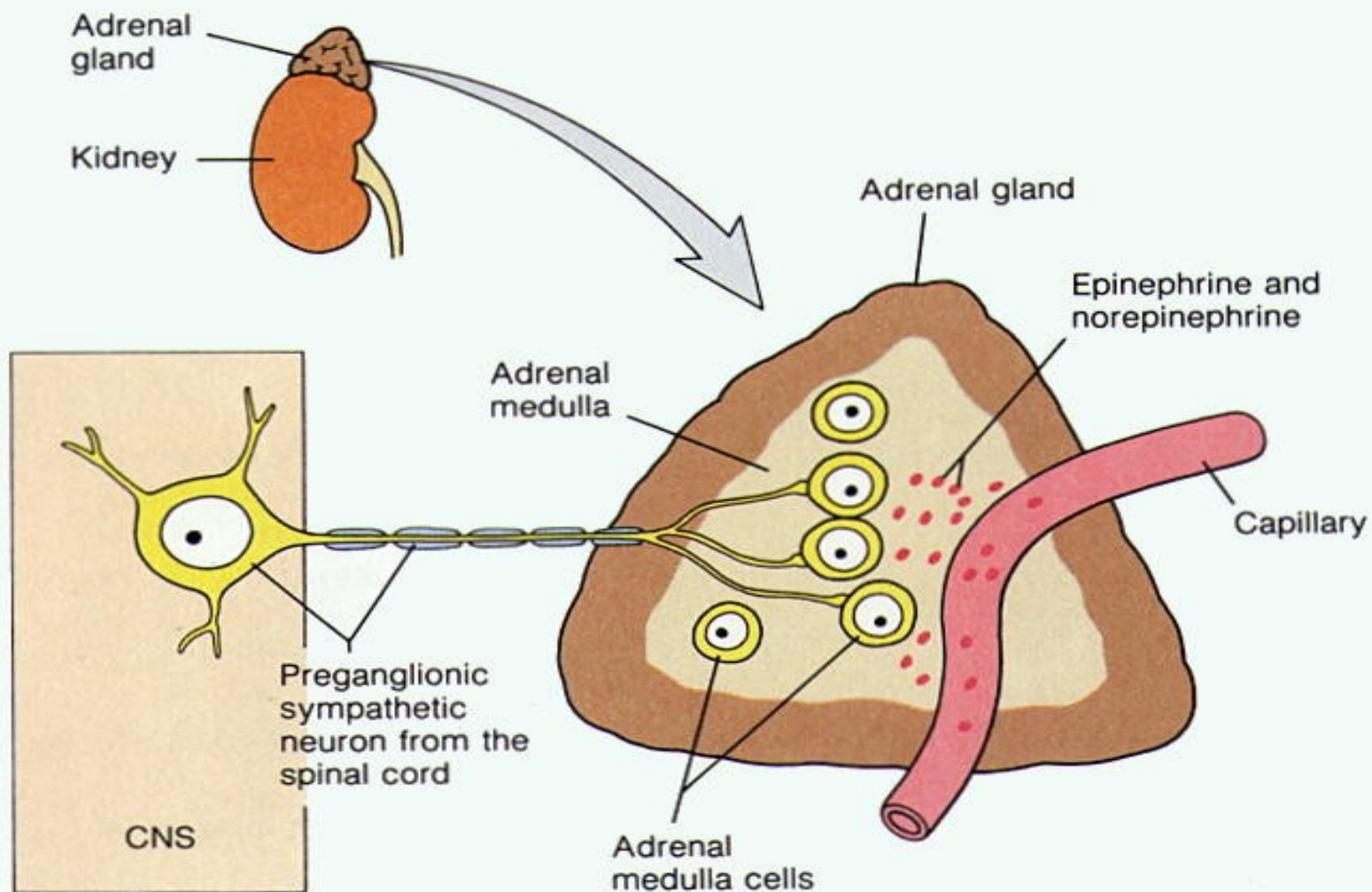
- Inner part - (20%) of the of adrenal gland.
- **Modified sympathetic ganglion** made up of chromaffin cells.
- Secretes catecholamines into blood.
 - 1- **Epinephrine.** (80%)
 - 2- **NE.** (20%)



The adrenal medulla



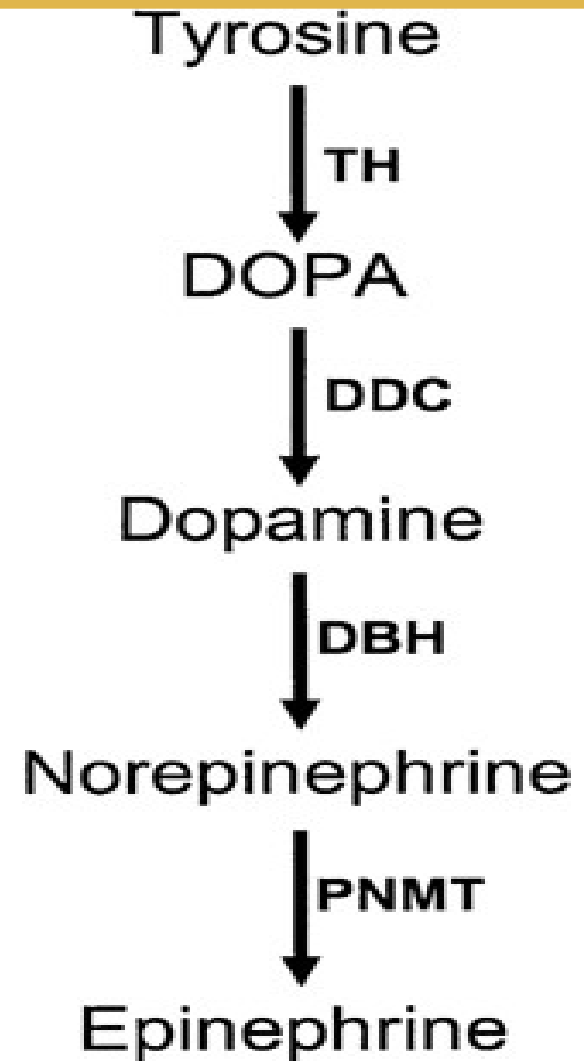
- The normal plasma level of free norepinephrine is about 300 pg/mL, but the free epinephrine level, which is normally about 30 pg/mL



The adrenal medulla



- The adrenal medulla contains the enzyme PNMT (**Phenyl ethanol-amine N methyl transferase**) which catalyzes the conversion of NE into epinephrine.
- Epinephrine & NE stored in granules □ secreted by Ach released from preganglionic neurons that innervate the gland.

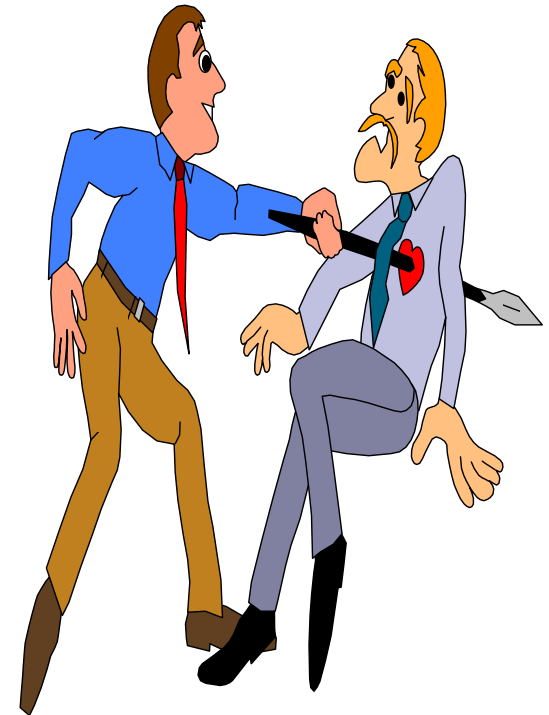


The adrenal medulla



- **During the fight-or-flight responses:**

- (+) of sympathetic nervous system with
- release of large amounts of catecholamines (mainly epinephrine).
- Augmentation & Generalization of sympathetic effects.



The adrenal medulla



Regulation:

n:

- Not only fight or flight responses (+) sympathetic input to the gland but different factors can ↑ catecholamines secretion, by increasing preganglionic sympathetic impulses to the adrenal medulla.

e.g.:

- Hemorrhage.
- Exposure to cold (hypothermia).
- Severe hypoglycemia.
- Severe exercise.

The adrenal medulla



■ Actions:

Metabolic effects

- CHO:
(+) glycogenolysis in liver & muscles \square \uparrow glucose
(Hyperglycemic).
(-) insulin & (+) glucagon.
- Fat :
(+) HSL \square

Smooth muscles

C.V.S

- \uparrow H.R (+ve chronotropic)
- \uparrow force of contraction (+ve inotropic)
- \uparrow COP.
- Generalized ...
- \uparrow ABP

C.N.S

(+) RAS \square \uparrow alertness

Respirato

Bronchodilatation

Contraction of sphincters
& relaxation of walls of GIT & U.T

The adrenal medulla



- Generally, E & NE have very similar effects on their target organs.
- However, adrenaline is the more potent in:
 - Heart: force of contraction & heart rate.....
 - Metabolic activities e.g glycogenolysis.
 - Airways: bronchodilatation.
- While noradrenaline has great effect on:
 - Blood vessels e.g peripheral vasoconstriction & blood pressure.

PHEOCHROMOCYTOMA



- A tumor of the adrenal medulla that secretes excessive amounts of catecholamines.
- **Symptoms:**
 - Severe hypertension.
 - Palpitation (T.C).
 - Hyperglycemia.
- **Diagnosis:**

Measurement of 24-hour VMA (vanillylmandelic acid) in urine.

Lecture Quiz



Q. Which of the following describes Addison's disease?

- a. It is accompanied by hyperkalemia & hyponatremia.
- b. It is accompanied by hypertension & hyperglycemia.
- c. May be accompanied by skin pigmentation.
- d. Metabolic alkalosis may occur.
- e. It must be associated with obesity.

Lecture Quiz



Q. Which of the following is true about catecholamines?

- (a) are secreted by the adrenal cortex.
- (b) reinforce the parasympathetic nervous system.
- (c) are important in the maintenance of blood pressure.
- (d) promote glycogen storage.
- (e) are secreted in response to hypothalamic stimulation.

SUGGESTED TEXTBOOKS



1. Ganong's Review of Medical Physiology ,
23rd edition, Chapter 22.
2. Guyton & Hall: Textbook of Medical
Physiology, 12e (77) [pages: 1696-1732]

